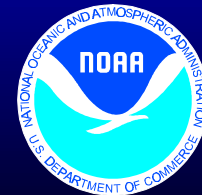


# NEXRAD Product Improvement

## Program Briefing to the DOC Budget Office

June 25, 2001



# What is NEXRAD

‡The Next Generation Weather Radar (NEXRAD) Program was created by the Department of Defense, the Department of Transportation, and the Department of Commerce.

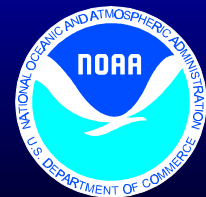
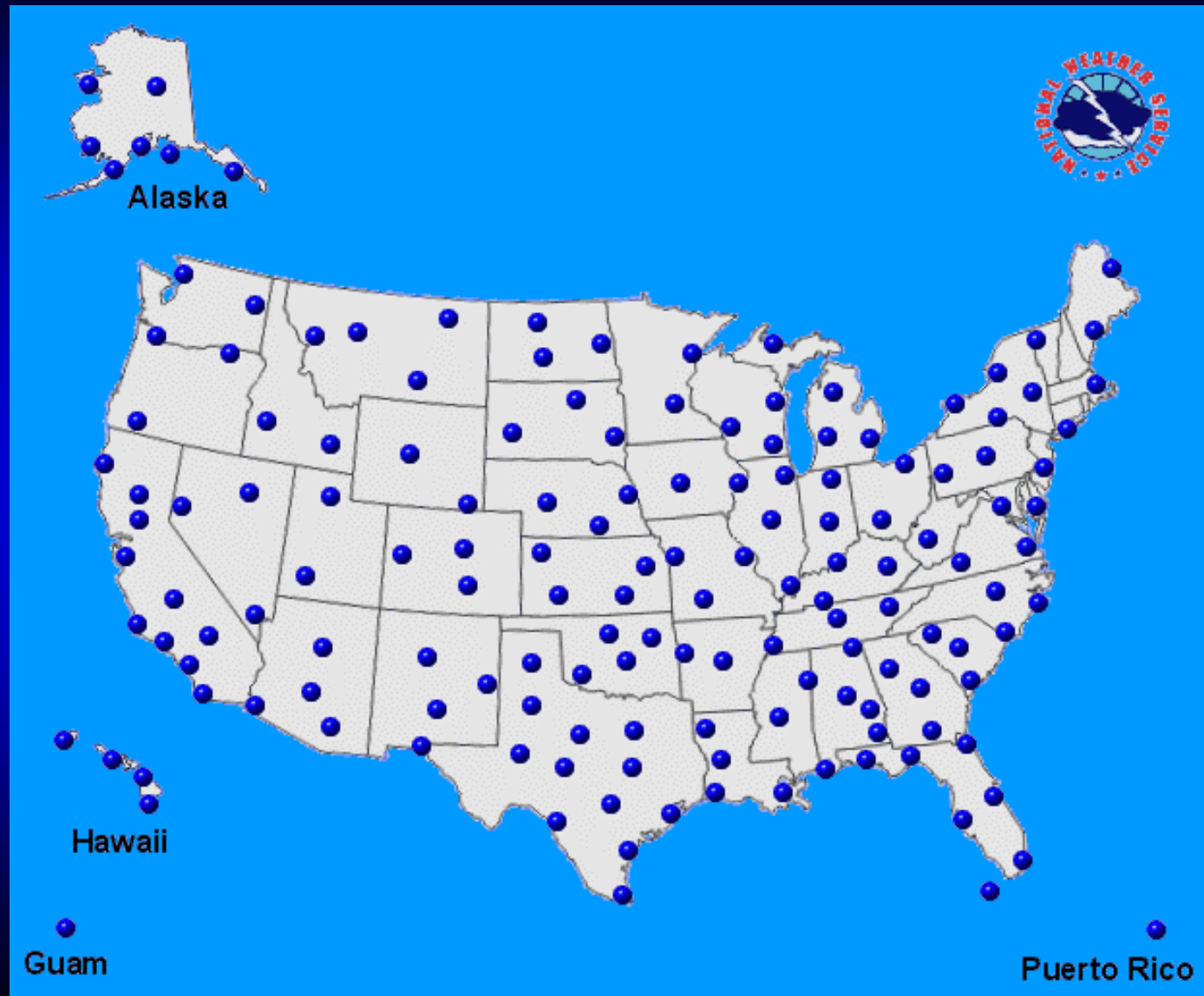
‡NEXRAD is a state-of-the-art, automated signal processing, pulse Doppler weather radar system that generates a wide array of automated weather information.

‡NEXRAD addresses operational requirements including early warnings of hazardous weather; flash flood predictions; general weather forecasts; flight safety; water resources management; and protection of resources on military installations worldwide.

‡The first operational WSR-88D was installed in May 1990 in Twin Lakes, Oklahoma. The remaining 161 units were installed by 1996.



# What is NEXRAD

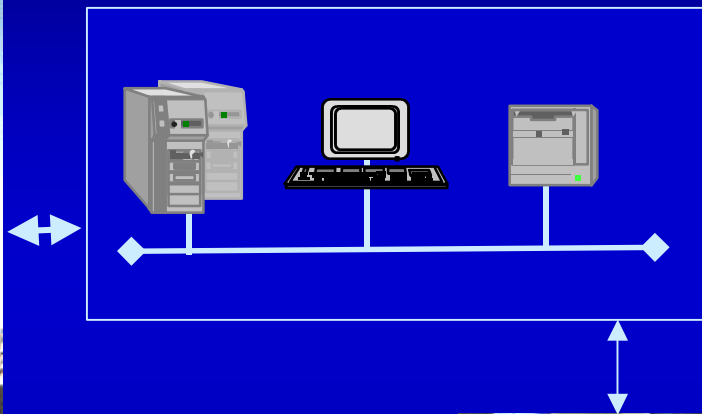


# What is NEXRAD

**RDA: Radar Data Acquisition**  
(Transmit energy, receive data)



**RPG: Radar Product Generator**  
(Scientific Processing)



**AWIPS: NWS Forecast Office**  
(Forecaster Warnings)



# NEXRAD Product Improvement

## What?

- ↓ NPI is an ongoing process of NEXRAD evolution for large scale improvements to WSR-88D technological and scientific capability
  - ↓ Infuse improved radar engineering & science into operations
  - ↓ Avoid technological obsolescence

## Why?

- ↓ Improve NEXRAD support to mission performance
  - ↓ Better detection of small scale tornadoes
  - ↓ Snowfall accumulation estimates
  - ↓ Aircraft icing conditions
- ↓ Maximize use of COTS components
  - ↓ Remove proprietary dependencies
  - ↓ Cost effective long term maintenance
  - ↓ Avoid 2nd major radar replacement initiative



# NEXRAD Product Improvement

## Current and Planned Projects:

- **Open Systems Radar Product Generator (ORPG)**
  - Replace 10-year old, proprietary computers with modern, open architecture workstations
  - Implement new science algorithms on a regular basis
- **Open Systems Radar Data Acquisition (ORDA)**
  - Replace 10-year old computer and signal processor with open architecture, workstations, and modern DSPs
  - Mitigate range/velocity ambiguity
  - Improve areal and temporal resolution of data collection
- **Dual Polarization (Dual Pol)**
  - Add linear, vertical polarization channel
  - Derive polarimetric variables for scientific processing





# NEXRAD Product Improvement

## Expected Results

- ↓ Improved tornado/severe weather warnings
  - ↓ Full resolution data for AWIPS SCAN program and base data displays
  - ↓ Faster, higher resolution VCPs (volume coverage pattern)
  - ↓ Range & Velocity folding mitigation



In 2000, 91% of all tornadoes were F0 and F1.

Performance Measures	Detection	Lead time
Pre Nexrad	37%	6 min
Current ('96-'00)	64%	11 min
With NPI Upgrades	80%	15-20 min



# NEXRAD Product Improvement

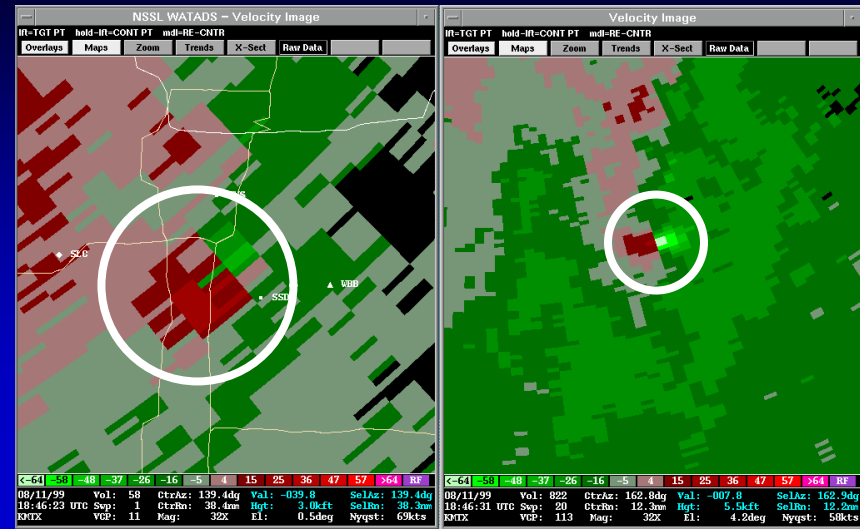
## Expected Results: ORPG

### ↓ Infrastructure

- ↓ Open operating system
- ↓ Graphical User Interface
- ↓ AWIPS/ORPG high speed interface

### ↓ New Science Applications

- ↓ Improved product resolution: 256 vs 16 levels
- ↓ Severe Weather indications 2 to 3 minutes earlier
- ↓ New and improved algorithms for snowfall, mesocyclone, downburst
- ↓ Improved data resolution
- ↓ Use of complementary FAA radar data





# NEXRAD Product Improvement

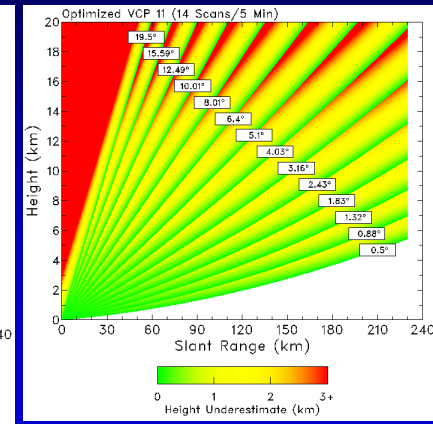
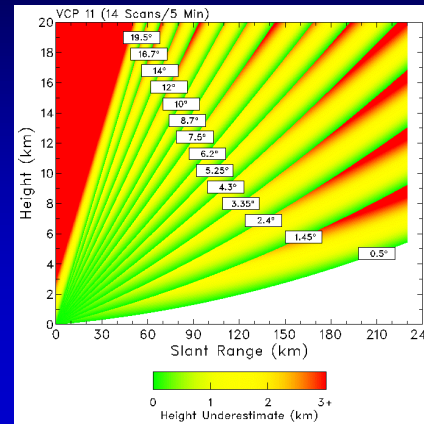
## Expected Results: ORDA

### ↓ Infrastructure

- ↓ Open operating system
- ↓ New Digital Signal Processor
- ↓ Graphical User Interface

### ↓ New Science Applications

- ↓ Reflectivity resolution  $\frac{1}{4}$  km vs 1 km now
- ↓ Data sampling  $\frac{1}{2}$  degree vs 1 degree now
- ↓ Improved velocity processing in range (both distance and folding)

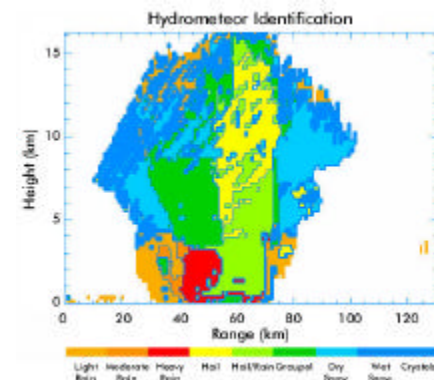


# NEXRAD Product Improvement

## Expected Results: Dual Polarization

- 1 Better rainfall estimates
- 1 Distinguish hail from rain
- 1 Distinguish snow, sleet and rain
- 1 Information on aircraft icing potential
- 1 Identify ground clutter, birds, insects

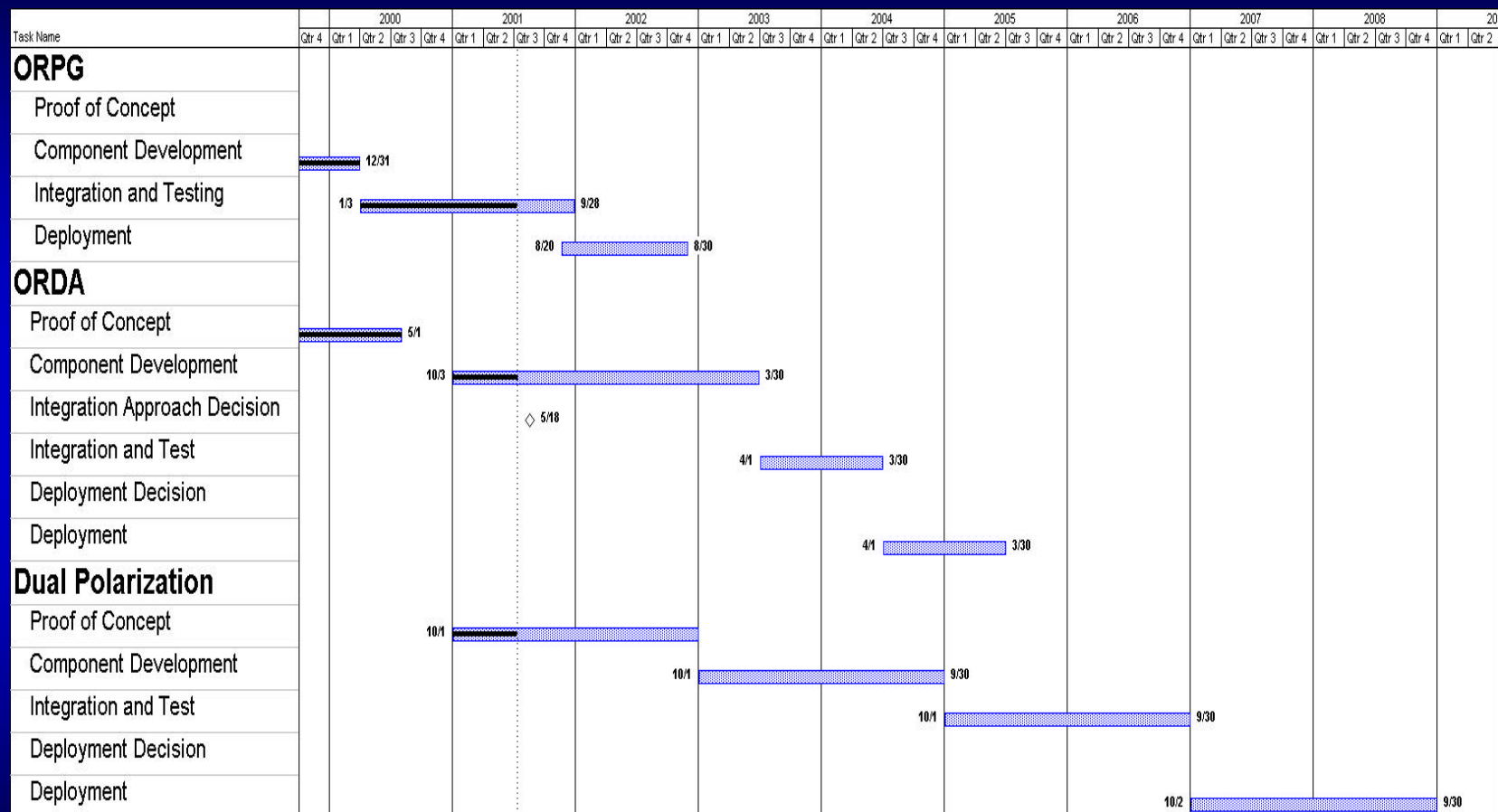
Classification of Hydrometeors in a Hailstorm



Dual Polarization will allow identification of different types of precipitation and better precipitation estimates



# NEXRAD Product Improvement Schedule



# NEXRAD Product Improvement

## Status

### 1 ORPG

- 1 System testing complete; Beta field testing beginning
- 1 Deployment to begin Sep 01 and complete in Aug 02

### 1 ORDA

- 1 Proof of Concept successfully operated over past year
- 1 Detailed System Design in progress, based on POC
- 1 COMMITTS contractor selected to finish development, integrate, test, procure and deploy

### 1 Dual Polarization

- 1 Proof of Concept activities to continue through FY 2002



# Budget

	FY00 & Prior	FY01	FY02	Cost to Complete	Total
ORPG	9223	5909	1196	70	16398
ORDA	1135	758	741	21646	24280
Dual Pole				34370	34370
Program Management	458	198	600	5466	6722
Technical Support	2670	897	1275	10000	14842
Other*			4450	4168	8618
Total	13486	7762	8262	75720	105230

\* Includes Critical Component Acquisition, Level II Data Acquisition, Precipitation Processing System, FAA Radar Integration



# NEXRAD Product Improvement

## Issues

- Stable funding profile
- Demonstration of Dual Polarization design and benefits





# **NEXRAD Product Improvement**

## **BACKGROUND**



# What Will Be Improved?

## RPG System Infrastructure

	Legacy	ORPG
Hardware	<ul style="list-style-type: none"> <li>• Limited computer Capacity</li> <li>• Inflexible architecture</li> <li>• Component obsolescence</li> </ul>	<ul style="list-style-type: none"> <li>• Excess capacity &amp; scalability</li> <li>• Flexible hardware architecture</li> <li>• Modern, commercial components</li> </ul>
Software	<ul style="list-style-type: none"> <li>• Proprietary Operating System</li> <li>• Unstructured</li> <li>• Fortran; limited "C"</li> </ul>	<ul style="list-style-type: none"> <li>• Open Operating System</li> <li>• Structured, modular, modern SW tools (ease of future SW/HW changes)</li> <li>• "C", "C++", Fortran supported               <ul style="list-style-type: none"> <li>- 73K SLOC Fortran ported</li> <li>- 331K SLOC new code C &amp; C++</li> <li>- 23K Other code (make &amp; scripts)</li> </ul> </li> </ul>
User Interface	<ul style="list-style-type: none"> <li>• Command line text; little used for RDA "fine tuning"</li> <li>• Data quality suffers; range folding, poor clutter suppression</li> </ul>	<ul style="list-style-type: none"> <li>• Graphical User Interface (55K SLOC); easy "fine tuning" of RDA parameters</li> <li>• Range folding minimization for storms; promotes better warning decisions</li> </ul>
Interfaces & Communications	<ul style="list-style-type: none"> <li>• Unique, inflexible interfaces to RDA &amp; product users</li> </ul>	<ul style="list-style-type: none"> <li>• Use existing interfaces for now; design enables future evolution to modern, flexible interfaces</li> </ul>



# What Will Be Improved?

## RPG Science Applications

Legacy	ORPG
<ul style="list-style-type: none"> <li>• 16-level data resolution for products</li> <li>• Algorithm indications of severe weather (TVS, MESO) at end of VCP</li> <li>• Limited number of products sent to AWIPS over narrow band link</li> <li>• Fixed, limited number of vertical layer products</li> <li>• Fixed, limited number of VCPs</li> <li>• No snowfall algorithm</li> <li>• No incorporation of rainfall rate bias</li> <li>• No bright band mitigation</li> <li>• Original Mesocyclone algorithm</li> <li>• No Downburst algorithm</li> <li>• No ingest or use of FAA radar data</li> </ul>	<ul style="list-style-type: none"> <li>• 256-level (full) resolution products</li> <li>• Intermediate output of indications as soon as criteria met—gain of 2 to 3 min</li> <li>• Unlimited sharing of information between ORPG &amp; AWIPS over LAN</li> <li>• User-selectable, freezing-level and other layers</li> <li>• New VCPs, e.g., more tilts at lower angles to improve vertical resolution</li> <li>• Snowfall and liquid water equivalent</li> <li>• AWIPS bias calculation fed to ORPG</li> <li>• Bright band and range bias mitigation</li> <li>• Improved NSSL Meso Algorithm</li> <li>• NSSL Damaging Downburst</li> <li>• Products generated from FAA data</li> </ul>



# What Will Be Improved?

## RDA System Infrastructure

Project Scope	Legacy	ORDA
Hardware	<ul style="list-style-type: none"> <li>• Little capacity for functionality enhancements</li> <li>• Inflexible architecture, Hardwired Signal Processor</li> <li>• Component obsolescence</li> <li>• Incapable of supporting Dual Polarization</li> </ul>	<ul style="list-style-type: none"> <li>• Immediate capacity to employ new signal processing techniques, and scaleable for future</li> <li>• Flexible hardware architecture, modern Digital Signal Processor</li> <li>• Modern, commercial components; reduced number of components</li> <li>• Designed as foundation for Dual Polarization</li> </ul>
Software	<ul style="list-style-type: none"> <li>• Proprietary Operating System</li> <li>• Unstructured</li> <li>• Fortran; proprietary language for Programmable Signal Processor</li> </ul>	<ul style="list-style-type: none"> <li>• Open Operating System for host computer</li> <li>• Structured, modular, modern SW tools (ease of future SW/HW changes)</li> <li>• Host computer to re-use ORPG subsystem; HSP/PSP functionality reprogrammed to use "C" in new DSP</li> </ul>
User Interface	<ul style="list-style-type: none"> <li>• Command line text; cumbersome to use</li> </ul>	<ul style="list-style-type: none"> <li>• Graphical User Interface</li> </ul>
Interfaces & Communications	<ul style="list-style-type: none"> <li>• Unique, inflexible interface to RPG</li> </ul>	<ul style="list-style-type: none"> <li>• Standard TCP/IP communications</li> </ul>



# What Will Be Improved?

## RDA Science Applications

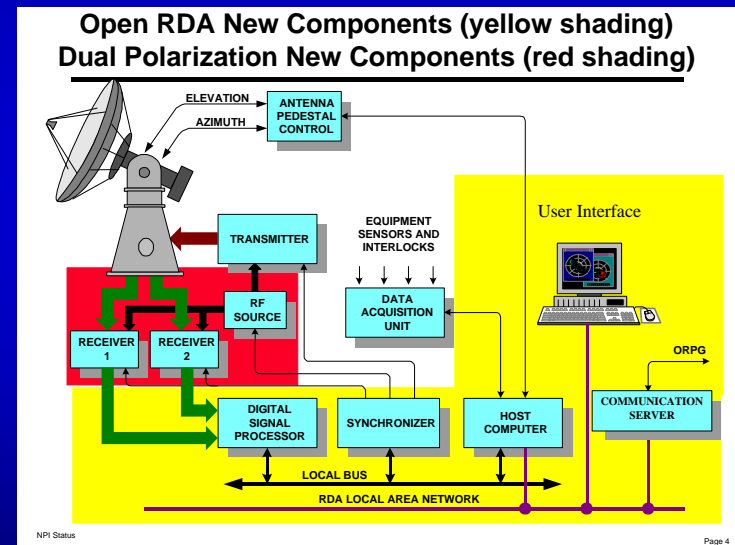
Legacy	ORDA
<ul style="list-style-type: none"><li>•Extensive range folding</li><li>•Reflectivity resolution of 1 km</li><li>•Velocity processing to 230 km</li><li>•Data sampling at 1 deg increments</li><li>•Single set of clutter filters for all users</li><li>•Signal to Noise threshold filtering at RDA</li><li>•Errors in calculation of Spectrum Width</li><li>•Reflectivity data from low angle Doppler scans, and Doppler data from low angle surveillance scans discarded</li><li>•Level II archive location restricted to RDA</li></ul>	<ul style="list-style-type: none"><li>•Implement range/velocity folding mitigation</li><li>•Increase resolution to <math>\frac{1}{4}</math> km</li><li>•Extend processing through 2<sup>nd</sup> trip</li><li>•Increase resolution to <math>\frac{1}{2}</math> deg increments</li><li>•Multiple streams of base data, varying filtering</li><li>•No SNR filtering at ORDA, values sent to ORPG for adaptive use by different programs</li><li>•Corrected Spectrum Width for better turbulence algorithm performance</li><li>•All data processed and sent to ORPG</li><li>•Level II archive can be moved to Offices, affording more reliable operation</li></ul>



# NEXRAD Product Improvement

## Actions in FY03

- 1 Implement Science Enhancement Builds for ORPG
- 1 Complete Development of Open RDA
- 1 Start Integration and Test of Open RDA
- 1 Continue Development/Testing of Range & Velocity Folding Mitigation
- 1 Begin Development of Dual Polarization





# NEXRAD Product Improvement

## Architecture

↓ Open System COTS Hardware and standards based software

↓ Open operating system

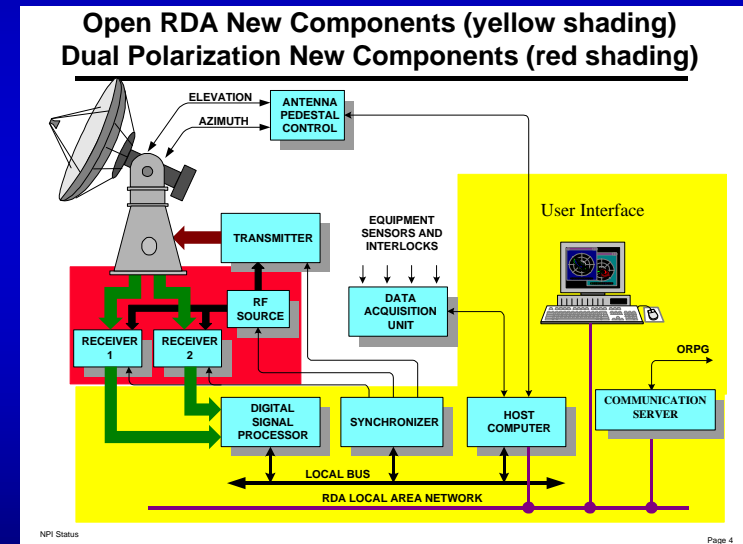
↓ Graphical User Interface

↓ AWIPS/NEXRAD LAN to LAN interface

↓ Modern Digital Signal Processor

↓ Structured, modular, modern software tools

↓ Number of ORDA LRUs reduced 75%



NEXRAD Open System Architecture



# NEXRAD Product Improvement

## Program Management

- ‡ On going Tri-agency Initiative (DOC, DOD, DOT)
  - ‡ NWS has management responsibility
  - ‡ Program Manager within NWS Office of Science and Technology (OST)
- ‡ ORDA to be procured using COMMITS Performance based contract
  - ‡ Contractor to use Government Developed Proof of Concept Design
  - ‡ Contract managed by Program Management staff
  - ‡ Contractor responsible for development, test and deployment



# NEXRAD Product Improvement

## Risk Management

- Use of ORDA Proof of Concept as basis for design
  - Reviewed by Lincoln Laboratory
    - Provides sound foundation for production system
    - Software suitable for production system use with minor modifications
- COMMITS Contractor to develop and deploy ORDA
  - Eliminates multiple organizations working on various aspects of acquisition
  - Managed from one Government office (NWS OST)



# NEXRAD Product Improvement

## Risk Management

- ↓ **Increase in Budget Accelerates Deployment**
  - ↓ **Mitigates component revisions due to changes in technology**
  - ↓ **Mitigates possible change in partner budget commitments**
  - ↓ **Mitigates loss of economies of scale procurements**
- ↓ **Joint Dual Polarization Experiment in FY02**
  - ↓ **Determine feasibility and utility of dual polarization**
  - ↓ **Cost-Benefit Analysis**
- ↓ **Security**
  - ↓ **ORPG is link to outside**
  - ↓ **ORPG Security Plan establishes security controls**



# What Will Be Improved?

## Dual Polarization Science Applications

- Improve precipitation estimates
  - ‡ Reduced attenuation from long radial extents of heavy rainfall
  - ‡ Discriminating rainfall from hail, clutter, birds, etc
  - ‡ Obtaining accurate estimates from 'partial beam blockage' areas
- ‡ Discriminate hail from rain; possibly gauge hail size
- ‡ Discriminate among dry/wet snow, sleet, rain in winter storms
- ‡ Remove bird impacts from velocity estimates: improve VAD Wind Profiles
- ‡ Identify chaff

